DIMENSIONS NBS

The magazine of the National Bureau of Standards U.S. Department of Commerce

May 1979

AS EINSTEIN EXPECTED. See page 8.

THE National Bureau of Standards joins with the many others who this year are celebrating the centennial of the birth of Albert Einstein. As a scientific institution, the Bureau is a direct heir to the legacy left by the great scientist. DIMENSIONS is highlighting two examples of how this heritage is being carried on at NBS. This issue discusses a recent experiment that reconfirms, with greatly increased precision, one of the foundations of Einstein's Special Theory of Relativity. (See page 6.) The July-August issue will report on how Einstein's theories are used in the daily work of calculating the effects of speed and gravity on a new, global system of time dissemination by satellite.

Albert Einstein Memorial
National Academy of Sciences
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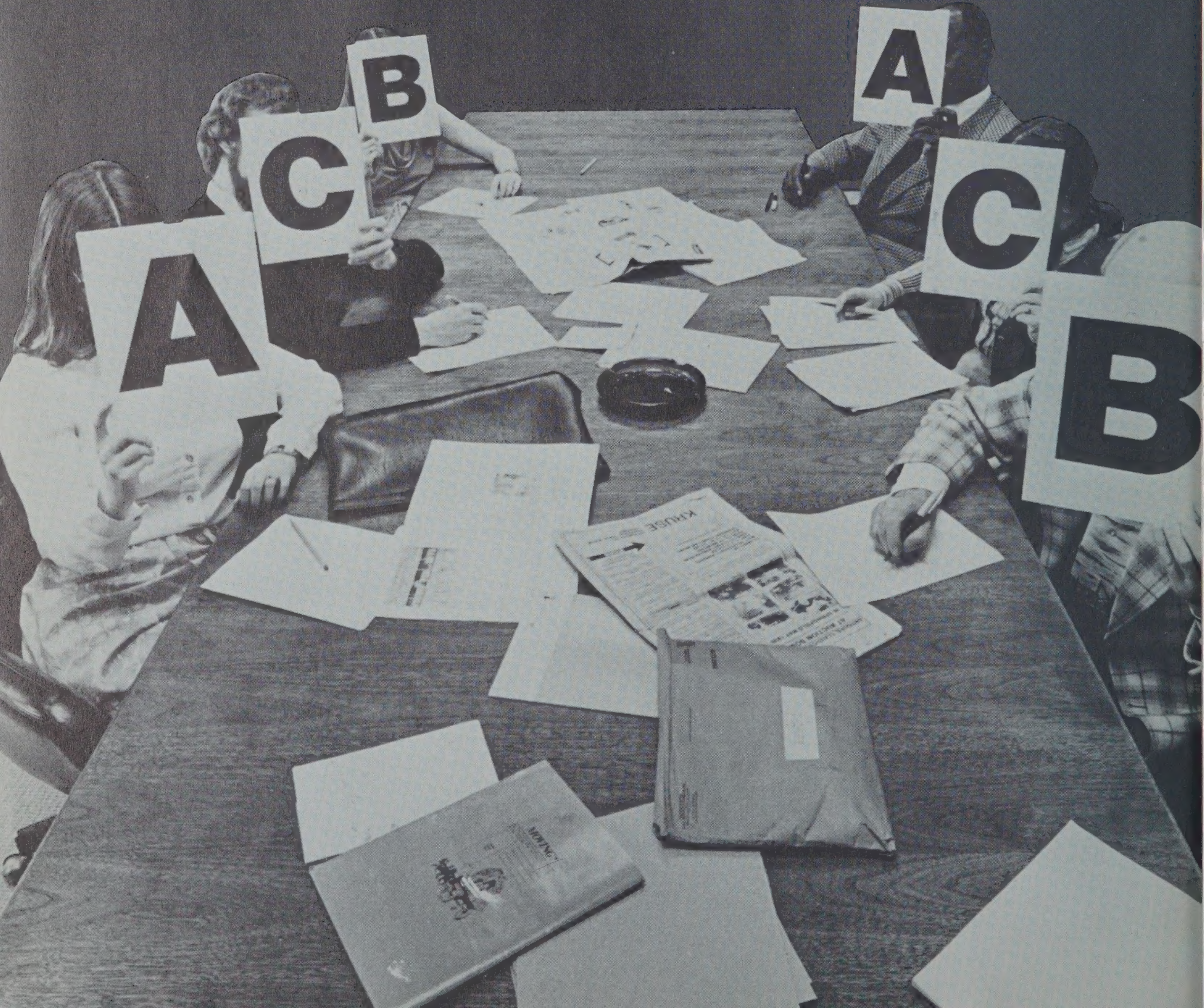

# of Group Decisions

"The great decisions of human life as a rule have far more to do with instincts and other mysterious unconscious factors than with conscious will and well-meaning reasonableness. The shoe that fits one person pinches another. There is no recipe for living that suits all cases."

—Carl Jung

by Charles R. Johnson

NO doubt you are wondering about the title for this article. No, this is not an existential treatise on the eclectic nature of man. Nor is it a protest piece on the frustrations of committee work and the joys of autocracy. It is instead the mathematical explanation of why committee meetings never seem to end—a logical proof that shows it is indeed impossible to reach a true group decision.

For the skeptics among you, a few examples should drive home the point.

Suppose a group of managers has been given the dubious honor of choosing which, if any, among a set of research proposals are worthy of funding. Each of the managers of the group will doubtless have ideas on the value of each proposal relative to the others. On the rare occasion that the group agrees with a particular ranking at the outset, the meeting is short and everyone leaves with a smile. But if, as in the more frequent example, the managers differ widely in their opinions, then the meeting could last hours longer and the smiles will most likely be fewer.

When a group runs aground in a sea of diverse opinion the common solution is to "vote on it." As the intellectual offspring of the Founding Fathers, we have been conditioned to believe that the vote is an unalienable right—our single most effective weapon against tyranny.

Unfortunately, the best known method of voting, the simple majority ballot, is not the great infallible voice of the people that it is generally considered. Simple majority voting suffers from a peculiar inconsistency known as the "voting paradox" which was discovered over 200 years ago.

Consider the problem of three managers, Smith, Jones, and Jenkins who must make a research funding decision. Their ranking by importance of the three proposals A, B, and C might look like this:

Smith—A, B, C
Jones—B, C, A
Jenkins—C, A, B

It is assumed that each individual has a "transitive" preference ordering: that is, if A is preferred to B and B is preferred to C, then A must be preferred to C. But because the group's opinion is so divided, simple majority voting cannot produce such a ranking. In this case, two managers like A more than B, two like B more than C *and* two like C more than A. Unless one of the manager's opinions can be changed, no decision can be reached.

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Johnson is an associate professor of applied mathematics and economics at the University of Maryland in College Park, and a part-time employee at NBS.

Assuming for a moment that these particular managers are firm in their beliefs, they may call in two additional colleagues, namely Waters and Wilson, to help settle the problem. This time the group adopts a more definitive voting rule, often called the Borda method. Each of the committee members ranks the proposals with a number, a 2 for the best proposal, a 1 for the next best, and a 0 for the worst. Their ratings can then be summed as illustrated below.

	Smith	Jones	Jenkins	Waters	Wilson	Result
Proposal A	2	0	1	2	2	7 best
Proposal B	1	2	0	1	1	5 next best
Proposal C	0	1	2	0	0	3 worst

With the addition of two more opinions, the group has now ranked the proposals, but it hasn't yet made a decision. They still don't know which, if any, of the proposals should receive funding.

Suppose they put the matter to a Yes-No vote. Each person will naturally vote consistently with previous rankings, but depending on how each committee member feels about "absolute" quality and standards, they may have different opinions.

Smith, for instance, may be convinced that all of the proposals are definitely worth funding. Waters and Wilson may have tougher standards. Although they think some of the proposals are better than others, they don't think any of them should be funded. Meanwhile, Jones and Jenkins might take a more moderate stand and decide to fund some but not all of the proposals.

The results of the Yes-No vote might be as follows.

	Smith	Jones	Jenkins	Waters	Wilson	Result
Proposal A	Yes	No	No	No	No	No funding
Proposal B	Yes	Yes	No	No	No	No funding
Proposal C	Yes	Yes	Yes	No	No	Yes, give funding

The curious outcome is that the proposal which the managers collectively felt to be the weakest is the only one to receive funding. Furthermore, if the group had stopped after their initial rankings and arbitrarily decided to fund only the top ranked proposal, their choice would have been A, and C would have received no resources at all.

Trying to eliminate such inconsistencies has occupied the contemplative minds of political scientists, economists, psychologists, and management analysts for generations. Pioneering work was done in this area, called social choice theory, during the 1950's by the Nobel prize-winning economist Kenneth Arrow.

Arrow tried to prevent inconsistent group decisions by creating some ground rules for voting procedures. He recommended that voting rules be required to meet five axioms which would ensure the rationality and equity of decisions.

The first of these axioms, according to an interpretation by economist Julian Blau, stipulates that the outcome of a voting rule must always show the property of *transitivity*. It must produce a ranking of alternatives which is free of logical inconsistencies—back again to if A is preferred to B, and B is preferred to C, then A is preferred to C. This, of course, rules out simple majority voting.

To ensure each individual's freedom of choice, a voting rule must allow an *unlimited domain*. In other words, it should be assumed at the outset that an individual may choose any possible ordering of alternatives. (ABC, BCA, CAB and so on.)

The third axiom requires that the outcome of the voting please as many people as possible. It must possess the *"pareto" property*, a term used in economic theory to refer to a distribution of resources such that no one can be made happier without making someone else less happy. Specifically, if all voters prefer alternative A to B, then A must rank above B in the outcome.

Next, of course, *no one individual can dictate* the final decision. A judgment reached by a dictator is certainly not a *group* decision.

And finally, the relative ranking of particular alternatives should hold across different situations. For example, suppose three managers decide at one meeting that proposal A is preferred to proposal B. Then at a subsequent meeting, additional proposals are considered. If they still prefer proposal A over proposal B then the added alternatives should not change the relative ranking of the two original pro-

posals in the final decision. This requirement is called the *independence of irrelevant alternatives* because the additional proposals should be irrelevant to the relative ranking of the original set.

The sad fact is that once Arrow had laid down these laws, he found that *no* voting rules made the grade. The now famous Arrow Impossibility Theorem states that given three or more individuals and three or more alternatives, there is no voting rule which will satisfy all the necessary axioms for rationality and fairness.

Still decisions must be made. In the absence of a perfectly fair and accurate way of incorporating different opinions, a group's conclusions will probably be the result of compromise. Hence, this may be one explanation for the existence of what is commonly called "politics." With no precise means of integrating individual priorities, there is a need for bargaining outside of the group process.

Bargaining does result in decisions, but it does not always effectively solve the problem. Thus even though they know there is no perfect solution, many researchers have continued to search for the best possible voting rule.

Many people have noted that simple majority voting satisfies all of Arrow's axioms except transitivity. By gauging the probability of an intransitive outcome (as the number of alternatives increases so does the probability of inconsistencies) a group can presumably use simple majority voting whenever the odds are good for a fair decision.

Others have tried to sway the odds in favor of voting consistency by placing restrictions on the number of alternatives allowable for any one decision—a breach of Arrow's second axiom.

Two NBS operations researchers, Theodore Wang and William Beine, and I have developed a ranking procedure based on the work of Thomas Saaty which we feel rationally combines all the elements needed for a decision (see box). Although we don't claim to have found a panacea we do feel our method affords a high degree of completeness and objectivity.

Finding a voting rule which always produces a "true" group decision is indeed impossible. But that won't keep committees like ours from trying to get as close as possible to the ideal.

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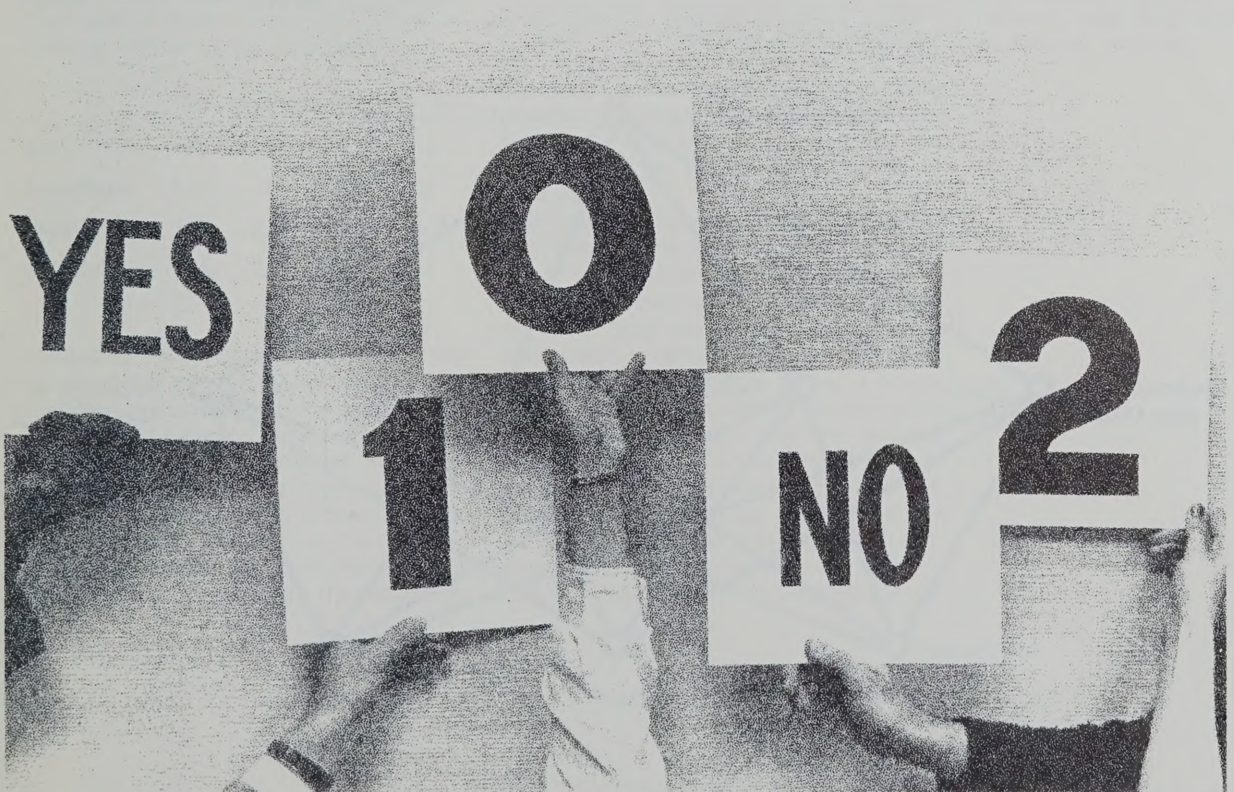


Choosing Wisely

The funding of scientific research is a big undertaking. Last year over $26 billion* was earmarked by the Federal Government in support of research and development. Each project in turn is a major investment often requiring tens of thousands or sometimes even millions of dollars.

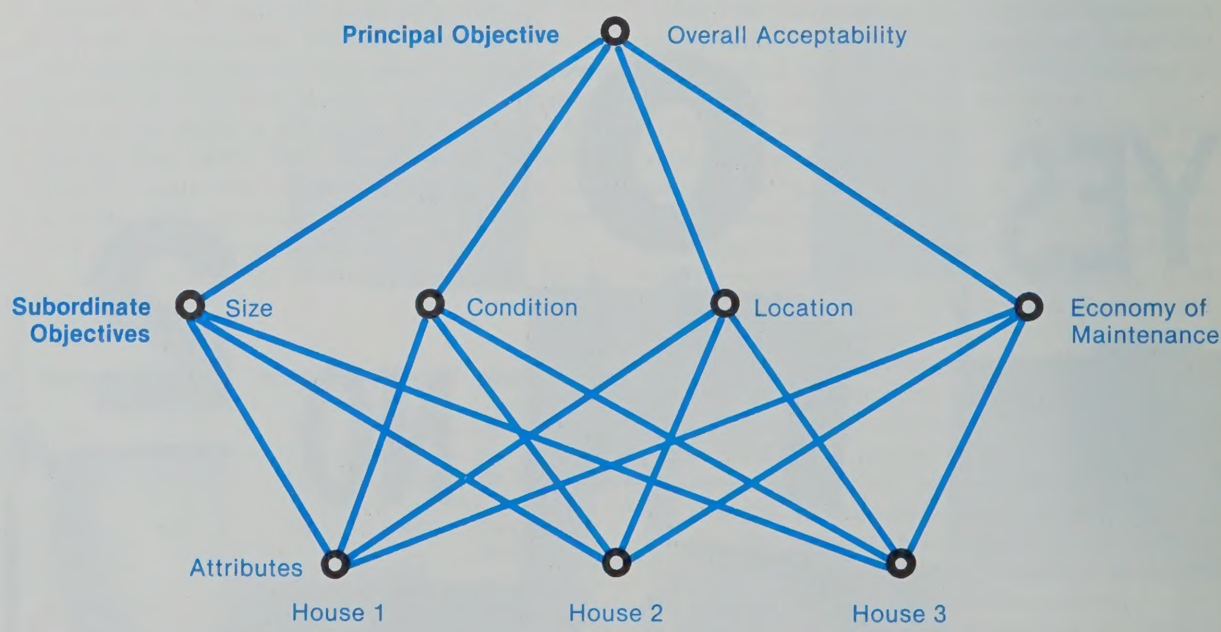
Decisions about which proposals to fund and which to reject are understandably difficult. Unfortunately, program analysts or managers asked to rank research proposals have no crystal balls to help them predict the success or failure of a proposed project. In the absence of clairvoyance, research proposal raters often rely on intuition and an overall assessment of one project relative to others to reach a funding decision. Typically, each rater assigns each proposal a score, and the proposal with the highest score receives the laurels. Sometimes these choices are made all the more difficult because a number of complex factors must be considered by the rater simultaneously.

* *Figure reported by the Office of Management and Budget, January 1979.*

While they make no claims of having found a magic formula for determining the Federal R&D budget, NBS operations researchers Theodore Wang and William Beine and mathematical economist Charles Johnson say they have developed a ranking procedure that could help managers. Basically, the technique, which was suggested by the work of Thomas Saaty of the University of Pennsylvania, consists of comparing two proposals at a time according to a hierarchy of objectives and characteristics.

This hierarchy is established by the raters and serves as a frame of reference for the ranking. The complexity of the hierarchy used naturally depends on the complexity of the ranking problem.

As a simplified example, consider the perennial problem of buying a house. A number of desirable characteristics will be important in making the final decision. The hierarchy for deciding which house of three possible choices will be the best buy might look like this:



Priority hierarchy for houses

For a more complex problem such as ranking research proposals, additional dimensions could be used to further break down the essential characteristics.

Once a hierarchy is agreed upon, the importance of each characteristic to the overall objective is determined using two-by-two comparisons. Each rater would be asked to decide how important one characteristic is to the principal objective in terms of another. For example, how important is size to overall acceptability compared to condition? How important is condition compared to location, and so on. Ratios used to make these comparisons would be determined using a scale which assigns specific meanings to specific numbers. For instance, a scale could be used where 1 indicated equal contribution to the objective; 2 indicated weak dominance of contribution; 3, moderate dominance; 4, strong dominance; and 5, absolute dominance. Conversely, the ratio 1/5 could mean absolute inferior contribution, 1/4 strong inferior contribution, and so on. The result of these comparisons would be a matrix similar to the following:

	Size	Condition	Location	Economy
size	1	2	3	4
condition	1/2	1	3/2	2
location	1/3	2/3	1	4/3
economy	1/4	1/2	3/4	1

Reading the matrix across each row, size is considered slightly more important than condition, moderately more important than location, and definitely more important than economy. Using a numerical evaluation technique designed to consistently represent the comparisons as closely as possible, each characteristic can be weighted according to importance. (Specifically, the weight for size divided by the weight for condition should equal or best approximate the comparison of size to condition, in this case a value of 2.)

From the above matrix the resulting weights would be:

size	=	**.48**
condition	=	**.24**
location	=	**.16**
economy	=	**.12**
		1.00

In other words, size can be thought of as providing 48 percent of the requirements for a good house, according to the comparisons used in this example.

The next step, then, is to make two-by-two comparisons of each of the homes with respect to each of the characteristics. How does house 1 rate on size compared to houses 2 and 3. How does house 1 rate on condition compared to houses 2 and 3? From these four additional matrices, each house can be assigned an overall weight or score with respect to each characteristic. If house 1 had scores of .8, .2, .75, and .4 for each of the characteristics (size, condition, location, and economy) respectively, then its overall score would be $.8(.48) + .2(.24) + .75(.16) + .4(.12) =$ total score.

Of course, the house with the highest total score would be the best buy, according to this system. Or, if a number of people are making the decision together, then their total scores could be averaged and ranked to decide which house to buy.

Whether the problem is buying a house, ranking research proposals, or evaluating alternative product designs, the purpose of such a system is to force each rater to express specific opinions. This method, says Johnson, should be used to "double check" the "gut feelings" that raters may have about the alternatives.

If the final decision is substantially different than expected, then the weights given to each of the characteristics can be reevaluated to see that they accurately reflect the group's feelings. In this way, the hierarchy can be used as a "sounding board" to help the group arrive at a decision. In actual practice the system involves behind-the-scenes mathematical finesse and a number of analytical considerations that cannot be treated in a simple review. But the basics of the technique and the role of the decision maker are the same.

The major drawback of this kind of decision-making process is the time involved to complete such extensive comparisons. Wang, Beine, and Johnson readily admit that employing such a rating system would take more of a rater's time than simply assigning one value to each alternative. Certainly all decisions are not important or complex enough to warrant the extra time. However, for major decisions which carry substantial impact, the researchers say this method can be a useful way of rationally and fairly combining a number of different opinions.

Space behaves as Einstein expected

by David Orr

COVER STORY

SCIENTISTS at the Joint Institute for Laboratory Astrophysics (JILA), Boulder, Colorado, have repeated with greatly increased precision a classic experiment to determine if, to an observer on earth, space has different properties in different directions. If found, this asymmetry would have revealed the earth's motions with respect to empty space, and thus violated one of the foundations of Einstein's Special Theory of Relativity.

The JILA effort is 4000 times more precise than the previous confirmation of this fundamental inquiry performed in 1964 at the Massachusetts Institute of Technology. By using highly sensitive laser techniques, the experiment provides the most sensitive measurement yet in support of Albert Einstein's Special Theory of Relativity. Coming during the centennial anniversary of Einstein's birth, the JILA results are an apt memorial to a genius of our time.

JILA is managed and staffed by the National Bureau of Standards (NBS) and the University of Colorado.

The stage was set for Special Relativity when, in 1864, the Scottish physicist James Clerk Maxwell made a strong case that light consisted of waves of electric and magnetic fields. Because all waves known at that time traveled through material media, Maxwell's theory suggested the existence of a medium which transmitted light waves. To maintain the mechanistic character of 19th century physics, scientists invented such a medium—the "ether"—pervading all space, and thus obligated themselves to prove its existence.

In 1887, A. A. Michelson and E. W. Morley performed one of the most famous experiments in the history of science. They attempted to detect the presence of the ether by monitoring the speed of light in various directions. Michelson and Morley expected to find different light speeds as they changed the direction of a light beam with respect to the earth's orbital motion through the ether. However, they found that light traveled a given path in a constant length of time, regardless of the path direction in space. They concluded that the speed of light was constant (independent of direction), that there was no ether, and thus that there was no way of measuring absolute motion.

Einstein based his Special Theory of Relativity on the Michelson-Morley results: the invariant speed of light and the relative nature of all motion. From these conditions, he showed that Galileo's description of motion was only an approximate one, that space and time are not absolute. Time and length intervals depend on an observer's motion relative to the clock and meter stick used in measuring the intervals.

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"The experimental bases of a theory as fundamental as Special Relativity must be reconfirmed when advances in experimental techniques allow still more sensitive tests to be performed."

But is Einstein's description of nature itself an approximation, albeit a much more accurate one than pre-Relativity classical physics? "Most theories are approximations," says Dr. John L. Hall, who with Dr. Alain Brillet performed the JILA experiment. "The experimental bases of a theory as fundamental as Special Relativity must be reconfirmed when advances in experimental techniques allow still more sensitive tests to be performed. Perhaps, somewhere out in the remote decimal places, we may find a deviation from what the theory predicts. Scientists would then need to revise the theory to match these findings."

Since Einstein revised our understanding of the universe, scientists have been doing their duty by demanding that his ideas withstand the most exacting scrutiny. For example, relativity predicts that a scientist will find no change in a length standard, at rest with respect to himself, as he changes its direction with respect to the earth's velocity through space. However, other versions of relativity theory suggest that, as a consequence of the earth's motion, a length standard may show a change with direction if a sufficiently sensitive experiment could be devised. If so, that measurement would be a means of sensing the absolute motion which Special Relativity denies. The JILA experiment was that measurement.

Hall, an NBS/JILA physicist, and Brillet, a JILA guest worker from France, did an experiment which was basically the same as that of Michelson and Morley, though the two groups interpreted their experiments differently. Michelson and Morley observed light waves to see if their behavior indicated the presence of an ether. Hall and Brillet observed light waves to see if they revealed a change in length of part of the experimental apparatus. In both cases, a positive result would have meant that absolute motion of the earth had been detected, and thus that speed of light depended on direction.

How, then, did the JILA scientists attempt to sense an unlikely aspect of space by measuring a miniscule length change which probably didn't exist? Answer: with great care. The search for a direction-dependent property of space was an experiment in which a barely perceptible response could change our theories of how space and time behave. Thus, the prime experimental requirement was a detection concept providing extreme sensitivity. Because frequency can be measured much more precisely than any other physical quantity, the JILA scientists designed their experiment so that a change in length would reveal itself as a change in the frequency of light waves.

Hall and Brillet used two lasers in their experiment. The lasers emitted light at two slightly different and nearly constant frequencies, one determined by a length standard and the other by a frequency standard. The researchers combined the two light beams to measure the frequency difference between them. This is the same phenomenon as the pulsations, or "beats," we hear when two musical tones are sounded together. A change in one of the laser frequencies would be seen as a change in the beat frequency.

The means by which the laser frequencies were held constant formed the crux of this experiment. One laser was stabilized by shining its light through methane gas, and then matching and locking its frequency to an invariant frequency at which the gas absorbed the light. The other laser was stabilized to a length by passing part of its beam through a glass-ceramic tube 30 centimeters long used as a spacer between two partly-reflecting mirrors. With the help of electronic controls, the stable distance between these mirrors was used to very precisely regulate the laser frequency.

The laser stabilized to the glass-ceramic spacer tube was the one employed to monitor the optical distance between the mirrors as a function of direction. The spacer tube itself was the sensing element. Hall and Brillet mounted this laser, the tube, and all the control electronics on a massive granite slab (12 × 40 × 95 centimeters) and placed the entire assembly on a turntable. The turntable, rotating six times per minute, caused the laser light reflecting between the mirrors on the ends of the frequency control tube to scan through every direction in the plane of the turntable. If the length of the tube or the speed of light were dependent on direction in space, the time for light to travel the length of the tube would vary. The control electronics would then display either effect as a change in laser frequency.*

The JILA result was the same as that of all previous tests of the uniformity of space: no change in light speed, no change in length. Happy anniversary, Albert—you're looking better than ever. □

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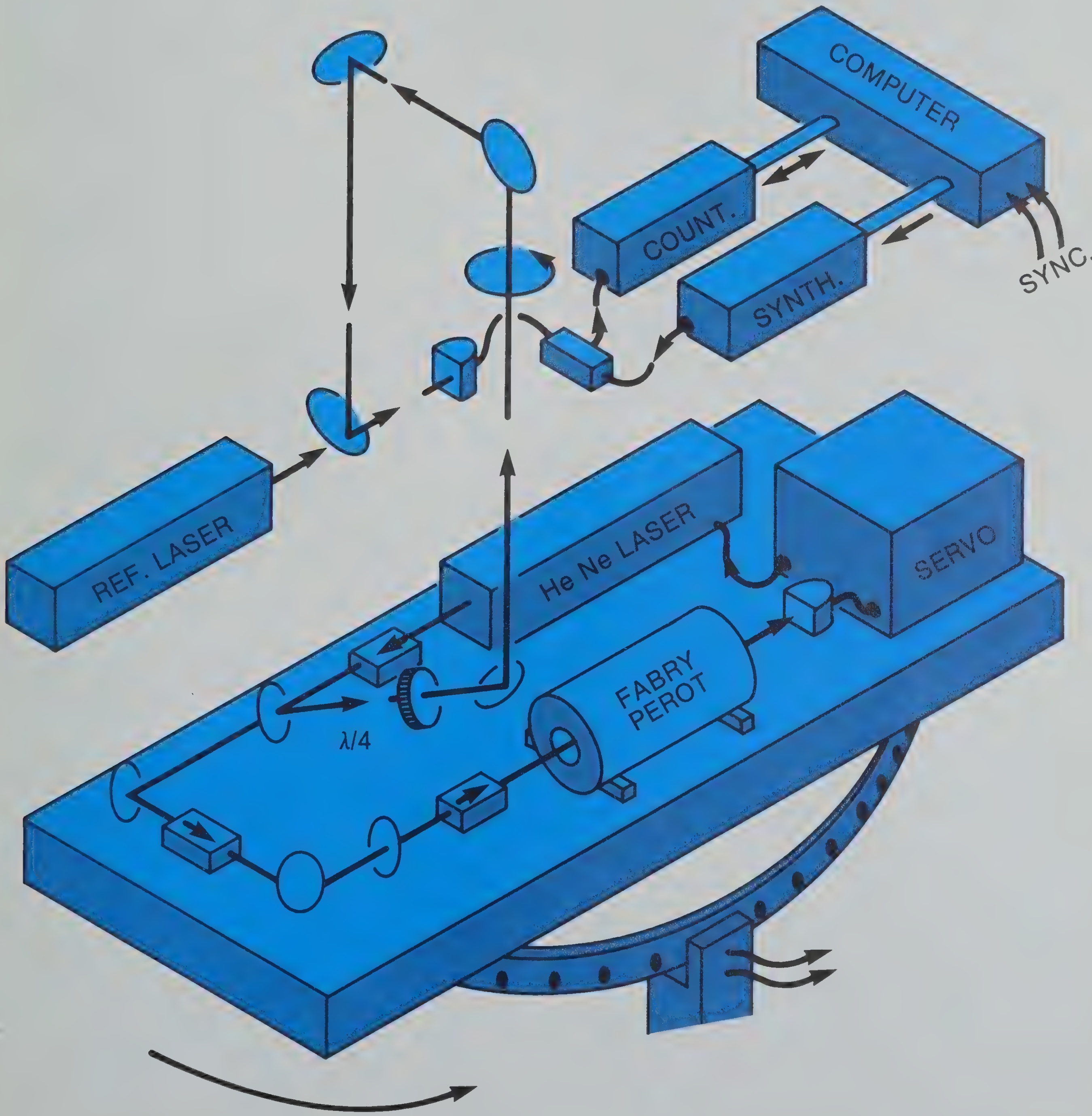
* *This work is described in the article "Improved Laser Test of the Isotrophy of Space," A. Brillet and J. L. Hall,* Physical Review Letters, *Volume 42, page 549, 26 Feb., 1979.*

APPARATUS FOR SENSING THE MOTION OF EARTH THROUGH SPACE. IF THE FABRY-PEROT SPACER CHANGED LENGTH AS IT REVOLVED RELATIVE TO THE EARTH'S MOTION, THE HELIUM-NEON LASER WOULD CHANGE FREQUENCY.



Colder than

by Juli Chappell and Kenneth Armstrong

NECESSITY is still the mother of invention. A new, small, portable refrigerator—one of the coldest in existence—is recent proof of this adage. The refrigerator can maintain an operating temperature close to absolute zero, the point at which a substance would have no heat energy.

Why would anyone want to achieve such extreme cold? The answer: to reach the temperature at which helium changes to a liquid. But this is an answer that becomes meaningful only when the full story is told, an adventure that touches several areas of human endeavor, from basic science to brain surgery.

The story starts with a man named James E. Zimmerman and a device called a SQUID.

For a fact, Dr. Zimmerman is a physicist with the Boulder, Colorado, laboratories of the National Bureau of Standards. He must also be a patient man. His research takes him, literally, far afield (from the tropics to the Arctic) and sometimes hinges on an unusual event in nature—like a total eclipse of the sun.

Zimmerman is interested in low-level magnetic effects, whether they involve anomalies in the earth's magnetic field or miniscule changes in human brain waves. His work depends on the use of a detector called a SQUID, an abbreviation for superconducting quantum interference device. A SQUID, which is a metal device no larger than a dime, is supersensitive to magnetic variations. For example, the presence of a mineral deposit deep within the earth alters the magnetic field on the surface, and a SQUID can register the effect. The device can also be used to monitor changes in brain waves such as those that occur when the eyes receive light or the ears sound.

With a SQUID, Zimmerman can pursue his professional interests wherever they may take him. There is a catch, however. The instrument is electrically superconducting (and thus supersensitive to magnetic effects) only when at or near the temperature of liquid helium—around 4 kelvins.* Traditionally, SQUID's have been cooled by submerging them during use in a bath of liquid helium. This substance can be difficult to obtain, and it evaporates quickly even with expert handling and well insulated working containers.

Liquid helium is produced and sold commercially in this and some other countries, but even in the United States, sources are few and supply is limited. "It takes about 2 liters of helium a day to keep a SQUID working," says Zimmerman. "That's allowing for about 50 percent evaporation, which is about what you can expect with good handling techniques. If we need it in the field where there is no source close by, that means it has to be shipped."

Transportation can be a real problem, he claims, because not all carriers are willing to provide special handling and because delays may mean the receipt of only an empty container. It is also a problem easily compounded, as Zimmerman has learned from experience.

In 1973 he traveled to central Africa to measure changes in the earth's magnetic field during a solar eclipse. Anticipating the absence of a liquid-helium supply in that area, he arranged—with some difficulty—for the shipment of two containers of the fluid from the United States. Only one arrived. A similar mishap occurred during an expedition to Alaska when again only part of a shipment reached its destination.

Luckily these incidents merely impeded but did not entirely obstruct either of the research efforts. But it was because of these events, says Zimmerman, that "I first saw the need for a small, portable cryogenic (very low temperature) refrigerator. If we had had something that could have eliminated the use of liquid helium—something we could take with us as part of our luggage—a big problem would have been solved."

Even more important, Zimmerman felt, "If a small cryogenic refrigerator could be developed, superconductivity and other cryogenic effects would find broader uses. They would no longer be the monopoly of a few specialists who have easy access to liquid helium and are expert in handling it."

Zimmerman's ideas meshed with an effort by the Navy to develop low-power coolers suitable for use with superconducting sensors and instruments. With Navy support, he was able in 1977 to design and construct a four-stage cryogenic refrigerator that could, with 50 watts of input power, cool from room temperature (about 300 K) to 8.5 K.*

This small power requirement was then more than 10 times lower than that of any experimental or

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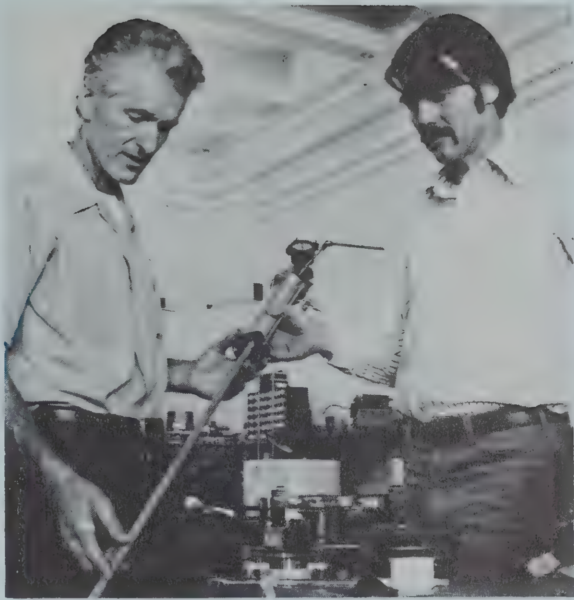
** A kelvin is the same interval of temperature as a degree Celsius. The difference is in the scales: Zero degrees Celsius (273.15 kelvins) is the temperature at which water freezes; zero kelvins is absolute zero. Scientists use the Kelvin scale to avoid calculations involving negative numbers.*

** See October 1977 DIMENSIONS/NBS, pages 24 and 25 for Zimmerman's report on this development.*

Cold



Physicists Dr. J. E. Zimmerman (left) and Dr. D. B. Sullivan hold the 3-kelvin refrigerator they developed in their laboratories at NBS in Boulder, Colorado.

commercially available cryogenic cooler, and in fact lower than most people probably thought possible. The refrigerator is also physically small—about a meter long and 10 centimeters in diameter—and it is a uniquely simple mechanism made of readily available materials. With it, Zimmerman demonstrated that a SQUID made of niobium metal could be cooled and operated with great reduction in the magnetic and mechanical noise generated by other experimental or commercial refrigerators.

Zimmerman's "cryocooler," as he called it, accomplished much of what he had hoped for. Certain kinds of SQUID's and other cryoelectronic devices would no longer be dependent on liquid helium. However, many such devices are made of materials with superconducting transition temperatures lower than the cryocooler could reach.

"This was too limiting to do what we really wanted—open up the use of superconductors to people who weren't experts in this area," says Zimmerman. "To do that, we had to get down to a temperature that would be cold enough for most superconducting devices."

That temperature is 4 K—the temperature at which helium liquefies.

Zimmerman turned for assistance to a colleague, Dr. Donald B. Sullivan, also of the NBS Center for Electronics and Electrical Engineering. Together, they developed a new refrigerator that more than "finishes" the cooling begun by the first device. It spans that last interval from 8.5 K to down below liquid-helium temperature—as low, in fact, as 3.1 K.

"Instead of trying to develop a single refrigerator capable of cooling from room temperature to liquid-helium temperature, we decided on two separate devices for better efficiency," says Sullivan. The scientists say that this two-system approach permits the designer to "optimize parameters such as working-fluid pressures for the temperature range covered by each system."

The new refrigerator, like its companion unit, is a model of simplicity, efficiency, and trouble-free design. It, too, is a little more than one meter long, has no valve, no piston rings, and is lubricated by the helium gas used as a cooling fluid. A small external electric motor requiring only a few watts of power drives the refrigerator, which has a cooling capacity of 4 milliwatts at 4 K.

Both NBS coolers are based on a reversal of the normal Stirling engine cycle. The Stirling engine—still a somewhat exotic device—uses external heat applied to a closed-cycle working fluid to produce power from the engine's crankshaft. In the NBS Stirling refrigerators, power from an external source (a motor) drives the crankshaft and the working fluid extracts heat from the device being cooled. Zimmerman and Sullivan believe that the unique factor in their final success is the use of low (below atmospheric) pressures in the Stirling cycle. They also believe that their new Stirling refrigerator is the first such device to reach liquid helium temperature without the use of the conventional Joule-Thomson expansion system (see box).

A special feature of both inventions is the exclusive use of epoxy-fiberglass composites and nylon for the moving parts. This construction, together with the low operating speed (about 1 stroke per second), results in low levels of magnetic noise and mechanical vibration, both of which are essential environmental requirements for most electronic superconducting instruments.

The low power requirements and small size of the refrigerators make them good candidates for portable cryocoolers to be used with SQUID's and other cryogenic instruments anywhere.

"We have what we need for work in the field," says Zimmerman, "a means of cooling SQUID's that we can take with us. The two refrigerators together are about as bulky as a pair of snow skis, so they're no trouble to transport."

Zimmerman is even more pleased at the increased potential he sees for use of cryoelectronic devices in places like hospital operating rooms. SQUID's, for instance, might be used to monitor brain waves during surgery. Zimmerman explains, "The SQUID's are simple to use if you don't have to work with liquid helium. Anybody can plug in a refrigerator."

Cardiology is another medical area that could benefit from cryoelectronic monitoring, and some heart specialists have already expressed interest in that possibility.

Of course, the Stirling refrigerators will have to be manufactured commercially before their advantages can be realized. "They're very simple to construct, so that should appeal to manufacturers," Zimmerman claims. "Also, they can be made of inexpensive materials, which should make them affordable." □

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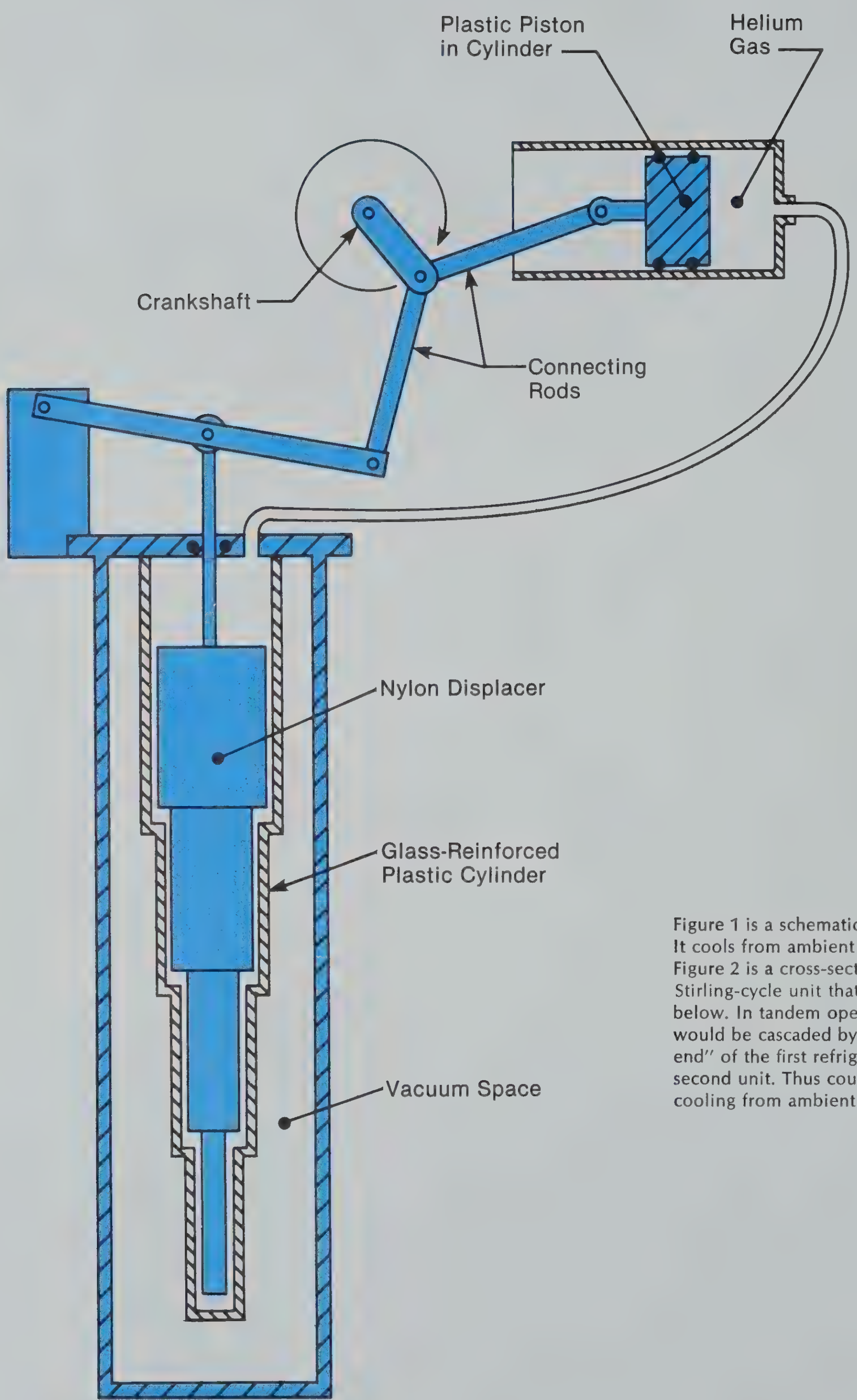

Figure 1.

Figure 1 is a schematic of the four-stage Stirling refrigerator. It cools from ambient temperature to 10 kelvins or below. Figure 2 is a cross-sectional drawing of the new single-stage Stirling-cycle unit that cools from around 10 K to 4 K or below. In tandem operation, refrigeration of the two units would be cascaded by a thermal connection from the "cold end" of the first refrigerator to the "hot flange" of the second unit. Thus coupled, the refrigerators could provide cooling from ambient to liquid-helium temperature.

Avoiding the Joule-Thomson Effect

The conventional Joule-Thomson or "JT" process, used for the final stage of a helium refrigerator or liquefier, is a counterflow heat exchanger and throttle (JT) valve at low temperature, and a 1- to 2-megapascal (10- to 20-atmosphere) room-temperature compressor. It has an advantage over the low-temperature Stirling machine and other machines which might be used in that there are no moving parts at low temperatures, and room-temperature compressors are highly developed and reliable. On the other hand, in a very-low-power refrigerator, the orifice of the JT valve must be exceedingly tiny and may be easily clogged by traces of lubricant or frozen impurities from the compressor.

The possibility of clogging the JT valve is enhanced by the fact that the relatively high-pressure compressor is a rather complex machine with pistons, valves, and bearings requiring lubrication, and rather elaborate measures are required to prevent contamination of the heat exchanger and JT valve. Also, the JT process is highly irreversible and inefficient compared to other thermodynamic processes such as the Stirling cycle, so that the mechanical or electrical power required to operate the latter should be much smaller than for the former. Low operating power itself may be a significant consideration for some applications. Furthermore, low operating power, small size, and relatively large clearances in the cold parts of a Stirling machine all serve to reduce problems with frozen contaminants which have been known to plague JT systems.

A Stirling machine has just five essential moving parts: two pistons, two connecting rods, and a double-throw crankshaft. The two cranks are arranged so that the pistons move approximately 90° out of phase. The working fluid, helium gas, is compressed by a piston in one cylinder. It is then moved, or "displaced," to the other cylinder where it is expanded by the second piston. Finally, it is displaced back to the first cylinder to be compressed again, completing the cycle. The heat of compression is thereby released at the first cylinder, and the heat of expansion is absorbed at the second.

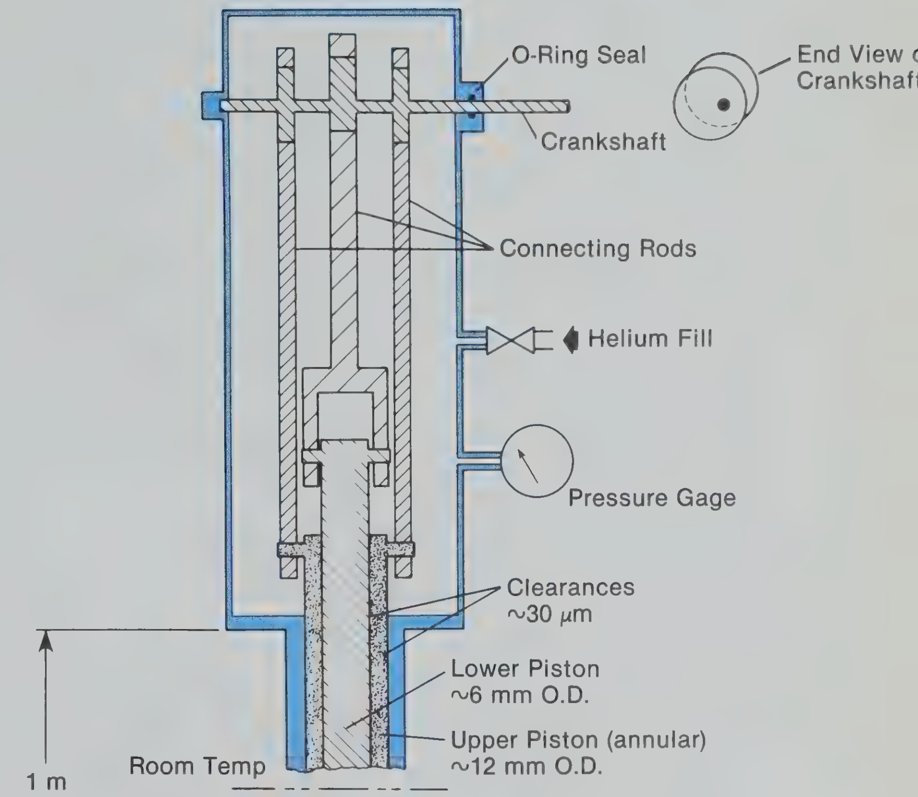

Figure 2.

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SMALL COMPUTER SYSTEMS EXCLUDED FROM INTERFACE STANDARDS

by Stan Lichtenstein

Following issuance of the new Federal channel level interface standards—*Federal Information Processing Standards* (FIPS) *Publications* 60, 61, and 62—the National Bureau of Standards released criteria (*Federal Register*, March 19, 1979) for excluding small computer systems from compliance with the standards and made available a "proposed initial exclusion list." Over 600 microcomputer, minicomputer, and other small systems were identified.

Comments on this proposed list were solicited and received by the Bureau's Institute for Computer Sciences and Technology. An official initial exclusion list will be issued and an announcement will be made in the *Federal Register* regarding its availability to the public.

The small computer systems involved are those costing the government less than $400 000. The purchase price applies to the "maximum normally employed configuration" of these systems. It includes all system hardware and operating system software for "tightly coupled" systems that are usually installed in a single room. "A primary concern in excluding small systems from the requirement to conform with the standards," the March 19 notice states, "is the cost of using such a complex interface relative to the cost of these smaller systems."

NBS has also announced (*Federal Register*, March 19, 1979) its procedures for keeping the public informed about the exclusion list and revisions to it. The Bureau will maintain a mailing list of vendors, Federal agencies, and other interested parties to whom copies of the current exclusion list will be sent on a regular basis. Persons wishing to receive this information should send a written request to the Director, ICST, NBS, Washington, D.C. 20234. Notice of any proposed revisions to the exclusion list will be published in the *Federal Register* and will be sent to all those on the mailing list. Forty-five days will be allowed for the receipt of comments concerning the proposed changes. NBS will then announce any revisions to the list in the *Federal Register* and will also notify those on the mailing list.

Lichtenstein is a writer and public information specialist in the NBS Public Information Division.

A POWERHOUSE AT NBS: PROPERTIES OF STEAM

Steam is an important working fluid or a source of heat in many industrial processes. For instance, power plants supplying electricity may be fueled by gas, oil, coal, or a nuclear reactor, but the electricity is produced by generators driven by steam turbines. Obviously, an accurate characterization of the various thermophysical properties of water and steam is of great importance.
Under the sponsorship of the National Bureau of Standards Office of Standard Reference Data, NBS and the University of Maryland are collaborating as part of an international effort in this area of research. Among several accomplishments, NBS researchers have demonstrated that the critical behavior of steam is completely analogous to that of nonpolar fluids, thus opening the door to applying new theories of critical behavior to steam; also, an NBS-UM team has, over the years, developed and refined a "scaled" thermodynamic potential that describes the thermodynamic and caloric data of steam in the critical region. UM researchers have developed an equation which has been adopted as the new international thermal conductivity equation for scientific and general use.

Anneke Levelt Sengers, NBS Thermophysics Division, A115 Physics Building, 301/921-2533, and Jan V. Sengers, Institute for Physical Science and Technology, University of Maryland, 301/454-4117.

Since the early 1930's, steps have been taken to formulate and standardize data on the thermophysical properties of water and steam by international agreement. These activities were originally coordinated by the International Conferences on the Properties of Steam, the first of which was held in 1929. In 1968, the International Association for the Properties of Steam (IAPS)* was established to give continuity and direction to these efforts. IAPS directs a number of international coordinated projects to assess the available information for water and steam in view of modern technological and scientific demands with the aim of updating and extending its Steam Tables and International Formulations.

The "Steam Tables" are a collection of tables, interpolating equations, and charts of the thermodynamic and transport properties of steam. Although many countries print their own national sets of Steam Tables, they are all based on a set of "Skeleton Tables" and a formulation which have been internationally agreed upon. (International skeleton tables for the thermodynamic properties of steam have existed since 1934). This country's current official Steam Tables, the ASME (American Society of Mechanical Engineers) Steam Tables, are based on the 1963 International Skeleton Tables for thermodynamic properties, the 1964 International Skeleton Tables for transport properties, and a formulation developed by the International Formulation Committee in 1967 (IFC 1967). They cover a range 0-800 °C in temperature and 0-100 MPa in pressure.

The work of IAPS has resulted in the adoption of new Skeleton Tables and formulations for the viscosity and surface tensions of water substance; these new formulations have been included in the revised edition of the "ASME Steam Tables" issued in 1977. More recently, agreement has also been reached on the representation of the static dielectric constant and on new representations of the thermal conductivity of water and steam. Recently, IAPS has been branching out in the area of aqueous solutions, principally motivated by the corrosion problems encountered in steam boilers and in turbine

**Dr. H. J. White, Jr., of the Office of Standard Reference Data at NBS is the executive secretary of IAPS.*

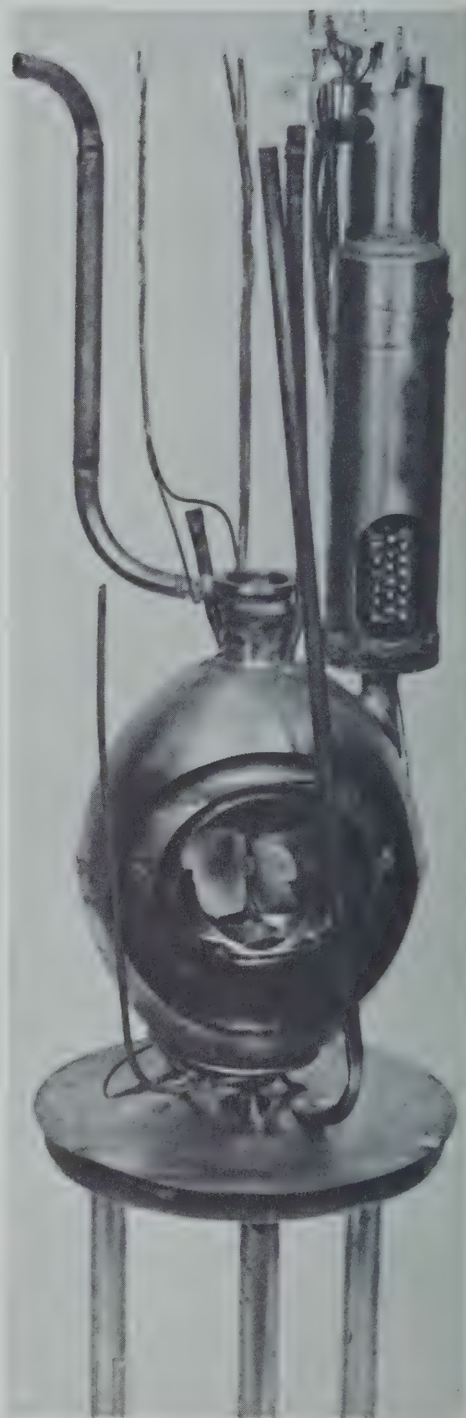

Figure 1—*Picture of a gold-plated calorimeter used at NBS in the 1930's for definitive measurements in the two-phase region of steam up to 375 °C.*

operation. Furthermore, IAPS is interested in the properties of heavy water, which are of importance in the design of nuclear reactors.

NBS involvement in the measurement and formulation of properties of steam has traditionally been strong. The backbone of the Skeleton Table and the IFC formulation is formed by the precise caloric and vapor pressure data for the two-phase region as obtained by N. S. Osborne, H. F. Stimson, and D. C. Ginnings at NBS in the 1930's. Forty years later, these data remain unsurpassed in accuracy. The gold-plated calorimeter in which the highly corrosive fluid was studied at pressures up to 22 MPa and temperatures up to 375 °C can be admired in the NBS museum (Figure 1).

In developing the IFC formulation, which was an early example of computer utilization in multiparameter fitting and tabulation, J. Hilsenrath of NBS played an important role. L. Haar, A. S. Friedman, and H. W. Woolley of NBS determined the thermodynamic properties of steam in the low density limit, which are incorporated in the IFC formulation.

Why does IAPS feel the need for extending and updating the present tables and formulations?

The first reason is connected with IAPS' expanding horizon. Although the range of the present tables is sufficient for power-generating purposes, this range is too limited for other categories of use. In particular, geologists need the properties of steam and brines at pressures beyond 100 MPa, and they express this need vocally at IAPS meetings.

The second reason is technical. Since the early 1960's, a large body of accurate thermophysical property data for steam has become available. Examples include: precise equation-of-state data in the critical region from the USSR, good quality equation-of-state data up to several hundred megapascals from the Federal Republic of Germany and from Japan, high quality equation-of-state data from the National Research Council in Canada, excellent specific-heat data from the Federal Republic of Germany, new thermal-conductivity data from France and Japan, and a most impressive set of thermal-conductivity data from the USSR, in the critical region as well as at high pressures and temperatures. At NBS, L. A. Guildner and co-workers have made new accurate measurements of the vapor pressure of water. All these new data underscore the need for an update of the Skeleton Tables and for a new, more accurate formulation of the properties of steam.

The third reason is scientific. It has become increasingly clear that the present tables and formulations have inadequacies, especially in the critical region. In the 1967 IFC formulation for industrial use, for instance, the pressure-tem-

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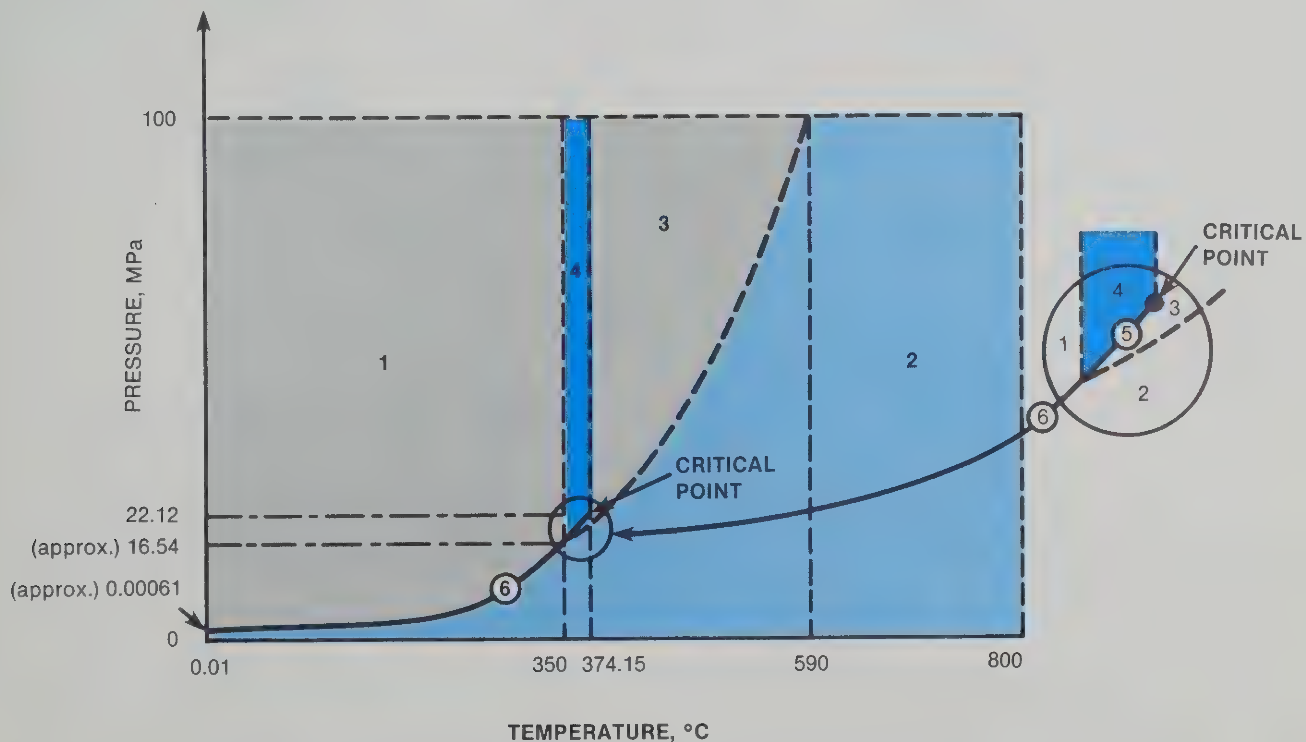

Figure 2—*Illustration of subregions in the pressure-temperature diagram used in specifying the 1967 IFC formulations for the thermodynamic properties of water and steam (from ASME Steam Tables).*

perature plane is divided into six subregions that were fitted independently, resulting in small inconsistencies across the boundaries (Figure 2). By the nature of the subdivision, all these inconsistencies converge in the critical region. The 1968 IFC formulation for scientific and general use suffers from the same defects. Also, this formulation is so cumbersome that it has never received general acceptance in the United States. Finally, the formulations for transport properties in the ASME Steam Tables ignore the enhancement of these properties in the critical region; the existence of these critical anomalies has been well established experimentally (Figure 3).

The need for one single representative equation for the thermodynamic properties for all pressures and temperatures was keenly felt at an early stage. The need became even more pressing as a result of the transitions from table-based to computer-based design of steam cycles. In 1968, Keenan and Hill at M.I.T. proposed a comprehensive equation for the thermodynamic free energy and the derived properties. The equation was based on a power series in density and in inverse temperature. However, a curious fact emerged. Although this formulation was quite accurate, systematic deviations appeared near the critical point. Similar work by Juza in Czechoslovakia had already shown that an inordinate number of terms would be needed to reproduce the thermodynamic property values accurately near the critical point.

A group headed by M. S. Green at NBS had made substantial progress in applying to fluids new theoretical ideas about

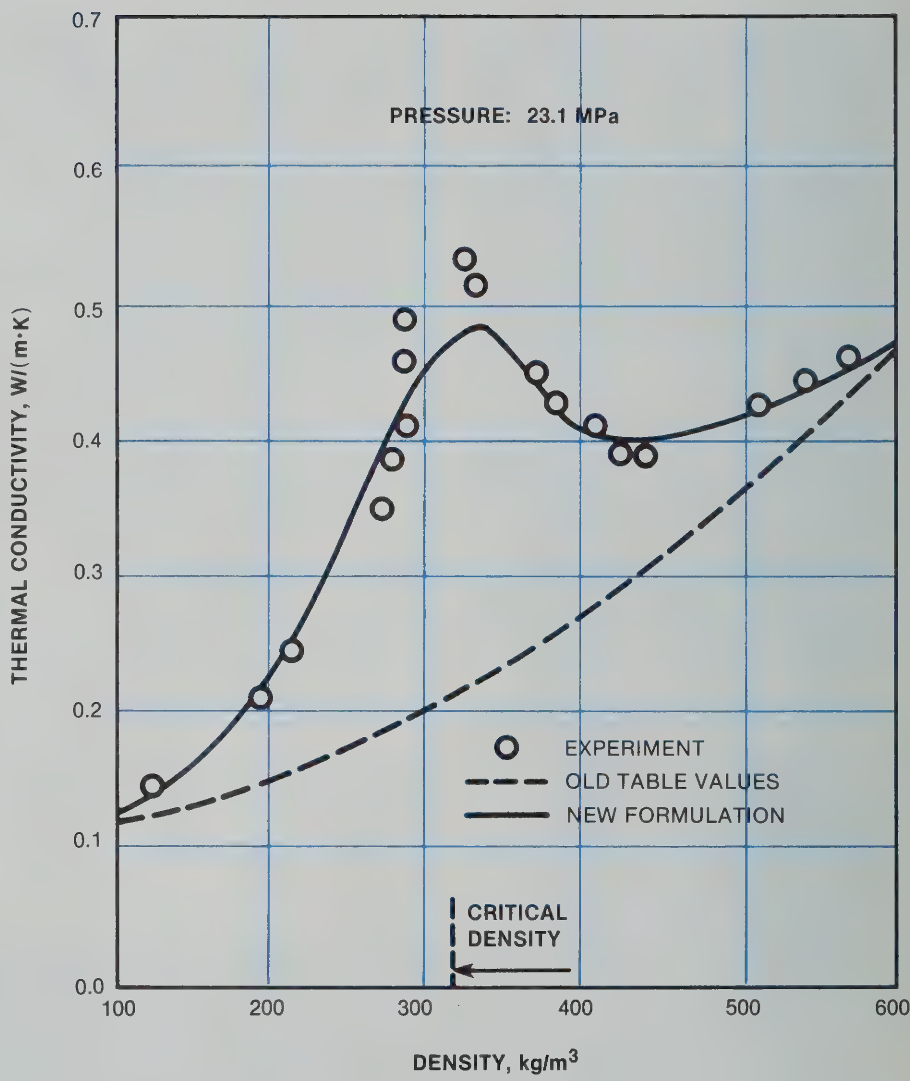

Figure 3—*Thermal conductivity of steam as a function of density at a pressure of 23.1 MPa.*

Circles: Experimental data obtained by Sirota et al. in the U.S.S.R.

Dashed curve: Values from 1964 Skeleton Table Charts.

Full curve: New formulation adopted by IAPS.

the anomalous nature of critical phenomena in alloys and magnetic and model systems. These new ideas implied that analytic equations such as those used by Keenan and Hill must fail near the critical point of fluids with short-range forces between the molecules (such as the Van der Waals forces).

Although there was at first some doubt that steam, with its strong dipolar interaction, would behave like simpler fluids, this doubt was dispelled when A. Levelt Sengers and S. C. Greer of NBS demonstrated convincingly that the critical behavior of steam is completely analogous to that of nonpolar fluids. In modern terminology, steam belongs to the same "universality class" as nonpolar fluids. The polar interactions are effectively short-range because of the rapid rotation of the molecules. This insight opened the door for applying the new theories of critical behavior to steam.

Professor J. Kestin of Brown University, then president of IAPS, requested NBS to revive its interest in the characterization of properties of steam. The "scaled" thermodynamic potential that we have formulated and refined over the years describes the thermodynamic and caloric data of steam in the critical region with good success and with a minimal number of adjustable parameters. Collaborators in this project have been M. R. Moldover and A. Levelt Sengers of NBS and F. W. Balfour, W. L. Greer, T. A. Murphy, and J. V. Sengers of the University of Maryland. This work needs to be complemented with the formulation of a representative equation for the thermodynamic properties of steam outside the critical region. This task is presently being conducted by L. Haar and J. S. Gallagher of NBS. They have proposed an equation that incorporates the molecular interactions in a realistic way so that it extrapolates well to high temperatures and high densities and will be effective in the large-range global description of thermodynamic data.

The understanding of critical phenomena has also progressed to the point that the anomalous critical behavior of transport properties can be related to that of thermodynamic properties. A special committee of IAPS, chaired by J. Kestin, had finalized a new set of Skeleton Tables for the thermal conductivity of steam and was ready for a new formulation. Using the scaled equation of state developed at NBS, R. S. Basu and J. V. Sengers of the University of Maryland, and J. T. R. Watson of the National Engineering Laboratory in Scotland, developed a representative equation for the thermal conductivity of steam that incorporated the observed anomalous behavior of the thermal conductivity data, and that at low densities reduced to an equation proposed by A. A. Alexander and A. R. Matveev in the USSR. This equation developed in international collaboration was reviewed by R. C. Hendricks of the USA and K. Scheffler of the Federal Republic of Germany. At the IAPS meeting held in Moscow in 1977, it was decided to recommend this equation as the new international thermal conductivity equation for scientific and general use. The values predicted by this equation for the thermal conductivity of steam at a pressure of 23.1 MPa are shown in Figure 3.

The use of the scaled representation of the thermodynamic anomalies in the formulation of the transport properties ensures that the critical divergences of compressibility, expansion coefficient, specific heat, thermal conductivity, and viscosity are described in a consistent way. What remains to be done is to unify the formulations of the thermodynamic behavior inside and outside the critical region.

The work on the properties of steam is a good example of how new scientific ideas can be applied to a problem of great practical importance, in an international setting and in an area in which NBS traditionally commands respect. The activities of IAPS, of which the NBS efforts form an integral part, will be reviewed by the 9th International Conference on the Properties of Steam to be held in Munich, Germany, in September 1979.

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STANDARD REFERENCE MATERIAL FOR SCANNING ELECTRON MICROSCOPE REISSUED

A magnification standard for scanning electron microscopes has been reissued by the NBS Office of Standard Reference Materials. The first issue, called SRM 484, consisted of 150 specimens. Demand for the SRM exceeded supply, and the new issue, SRM 484a, comprises 250 samples.*

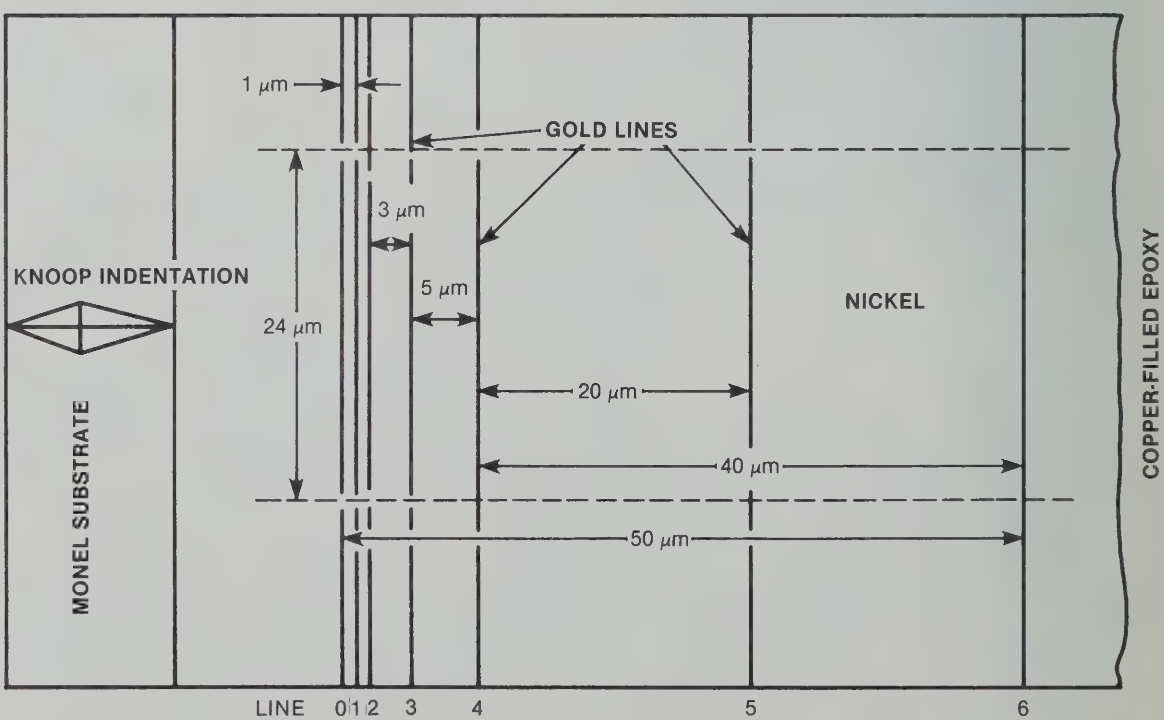
David B. Ballard, Metal Science and Standards Division, B106 Materials Building, 301/921-3603, and Fielding Ogburn, Chemical Stability and Corrosion Division.

Standard Reference Material SRM 484a, a stage micrometer scale, is intended for use in calibrating the scanning electron microscope (SEM) magnification scale to an accuracy of 55 percent or better within the range of 1000 to 20 000X. Each SRM bears an identification number and has been individually measured.

The certified distances between the centers of specific lines opposite the Knoop indentation (see the sketch) are provided with each SRM together with a photomicrograph that shows the area used in the measurement. The certification is valid within an area 24 μm wide centered about a line extending from the Knoop indentation.

The distances between the lines were determined from measurements made on photographs taken with an SEM in which each SRM was compared by substitution with a Master Standard; thus each reported interval has been corrected for SEM magnification drift. The operating conditions of the SEM were monitored and a resolution of 0.050 μm was main-

* *For a discussion of SRM 484 and a Research Material RM-100, for scanning electron microscopy, see the February 1977 DIMENSIONS/NBS, pages 26 and 27.*



tained using an SEM resolution test specimen.

The Master Standard was calibrated by an interferometry technique using a helium-neon iodine stabilized laser as the length standard in the NBS Mechanical Processes Division. The uncertainty of this calibration, based on 160 independent measurements on each spacing, is 0.006 μm for distances from 1 to 50 μm.

The total uncertainty for each distance of 1 through 5 μm is 0.039 μm, and for the 50-μm distance is 0.476 μm. The total uncertainties are the linear sums of the uncertainties associated with the Master Standard calibration and the comparison of each SRM with the Master Standard.

The polished surface of each SRM has been carefully ground and polished using metallographic techniques. The carbonaceous contamination (a product of SEM electron beam bombardment) can be removed by light hand polishing on a stationary surface covered with micro cloth using metallographic 0.05-μm γ-alumina powder. This cleaning process does not alter the certified spacing of the lines by more than 0.010 μm. Other cleaning techniques that remove surface material sufficient to obliterate the Knoop indentation will void the calibrated distance values.

A recommended procedure for calibrating the magnification of the SEM using SRM 484a and a list of parameters that may affect the resultant magnification of an SEM are included in the certificate that accompanies the SRM.

SRM 484a is available for $247.00 from the Office of Standard Reference Materials, B311 Chemistry Building, NBS, Washington, D.C. 20234.

Figure 1—*Schematic diagram showing the nominal distances between pairs of the gold lines in SRM 484.*

TWO ALUMINUM SRM'S AVAILABLE

The NBS Office of Standard Reference Materials announces the availability of two new SRM's for wrought aluminum alloy certified for their chemical composition.

Standard Reference Material (SRM) 1258 is Wrought Aluminum Alloy 6011 (Modified) and SRM 1259 is Wrought Aluminum Alloy 7075. Both have certified concentrations of silicon, iron, copper, manganese, chromium, nickel, zinc, magnesium, and beryllium. These SRM's are in the form of annealed disks, 35 mm (1⅜ in) in diameter and 19 mm (¾ in) thick.

Applications in product design: The 6011 alloy is used for truck and marine structures, railroad cars, furniture, etc. The 7075 alloy is used for structural parts of aircraft and also for keys and hydraulic fittings.

These aluminum alloy SRM's were prepared in a cooperative Industry-ASTM-NBS program and are designed primarily for use in optical emission and x-ray spectrometric methods of analysis. In addition to NBS, five laboratories cooperated in the analytical program for certification.

Three additional aluminum-base SRM's having different compositions are being developed as a part of this program. They are SRM C1255 (Casting Alloy 356) and SRM C1256 (Casting Alloy A380), which are planned for issue as disks approximately 64 mm (2½ in) in diameter, and SRM 1257 (High-Purity Aluminum), also planned for issue as disks approximately 38 mm (1½ in) in diameter. Serving as "Benchmarks," these five SRM's will provide both producers and consumers with primary reference materials.

SRM's 1258 and 1259 may be purchased from the Office of Standard Reference Materials, Chemistry Building, B311, National Bureau of Standards, Washington, D.C. 20234 for $64 per unit.

CONFERENCES

For general information on NBS conferences, contact JoAnn Lorden, NBS Public Information Division, Washington, D.C. 20234, 301/921-2721.

18TH ANNUAL ACM/NBS TECHNICAL SYMPOSIUM

The 18th annual technical symposium of the Association for Computing Machinery (ACM) Washington, D.C., chapter and the National Bureau of Standards' Institute for Computer Sciences and Technology will be held June 21, 1979 at NBS Gaithersburg, MD, headquarters.

The theme of the symposium is "Information Systems—Effectiveness for the User." It will be concerned with both good technical design of systems and their fulfillment of the human or organizational purposes they are intended to serve.

Papers will focus on how automatic data processing professionals can design and deliver user effective systems for mutually reinforcing man-machine interactions. Some of the leading topics will be:

- Computing for the handicapped user.
- Design of information systems.
- Design management and utilization of data base systems and data base networks.
- Documentation of systems and procedures, user training, and post-implementation audit and review.
- Supercomputers.
- Evaluation and validation of the performance of hardware, software, or firmware.
- Interfaces between users and data bases.
- Large-scale applications.
- Novel applications, techniques, and hardware.
- Personal computing, and possible faces with large computers and data bases.

For further information concerning the symposium's technical program, write to Angela Turvey, 4910 Butternut Drive, Rockville, MD 20853.

SYMPOSIUM ON EDDY CURRENTS

The first symposium to be devoted exclusively to eddy current characterization of materials and structures will be held at the National Bureau of Standards, Gaithersburg, MD, September 5-7, 1979.

The symposium is cosponsored by NBS, the American Society for Nondestructive Testing, and the American Society for Testing and Materials in cooperation with the IEEE Magnetics Society and the IEEE Power Engineering Society.

The purpose of the symposium is to bring together scientists and engineers from private industry, universities, and government laboratories to discuss the state-of-the-art of eddy current characterization of materials and structures and to stimulate developments in the field.

The term eddy current generally refers to currents induced in a substance through the variation of an applied magnetic field. Eddy current techniques are used to reveal surface and shallow defects in ferromagnetic and electrically conducting materials.

The symposium on Eddy Current Characterization of Materials and Structures will feature discussions of all aspects of theory, experiment, and application. Topics to be presented include:

- Theoretical analysis of fields, defects and structures.
- Measurement methods and instrumentation.
- Applications to materials properties and discontinuities.
- Data analysis, automation, and display methods.
- Calibration methods and standards.

To register for the symposium write to Kathy Stang, B348 Materials Building, NBS, Washington, D.C. 20234, or call 301/921-3295. A fee of $90 is being charged to all attendees to help defray the costs of conducting the symposium.

IMPROVING MATERIALS TO INCREASE USE OF COAL

The role of materials research in energy technology—specifically as it relates to increasing the use of coal as an energy source—will be the subject of a 3-day conference at the National Bureau of Standards, Gaithersburg, MD, October 9-11, 1979.

The Fourth Annual Conference on Materials for Coal Conversion and Utilization is sponsored by NBS, the Electric Power Research Institute, the U.S. Department of Energy, and the Gas Research Institute.

Using coal efficiently, and in an environmentally acceptable way, depends on the application of several developing technologies. There are a number of materials problems impeding the implementation of these technologies, however. The purpose of this conference is to provide a forum for the discussion of potential solutions to these problems by engineers and scientists from private industry, universities, and government laboratories.

The conference will feature a general session in which authorities in the field will discuss their views on materials design requirements for the coal conversion, coal utilization, magnetohydrodynamics (MHD), and emerging structural ceramics areas. In addition, there will be four technical sessions on:

- Metals for coal conversion, high temperature applications: corrosion, sulfidation, physical properties, and alloy development.
- Metals for coal conversion, low temperature applications: corrosion in liquefaction processes, fracture mechanics of pressure vessel steels, and alloy developments.
- Ceramics and refractories for coal gasification, MHD, and structural applications.

• Materials for direct utilization of coal: heat exchanger and turbine materials.

Keynote speakers will lead off each technical session; they will be followed by a panel discussion by well known investigators in the field, who will also highlight their own areas of research. Questions and comments from the audience will be encouraged to make the conference as informative and useful as possible.

To attend the conference, write to Kathy Stang, B348 Materials Building, NBS, Washington, D.C. 20234, or call 301/921-3295.

CONFERENCE CALENDAR

June 4-6
SYMPOSIUM ON WEAR AND CORROSION, Carnegie Institute, Washington, D.C.; sponsored by NBS and American Chemical Society; contact: Robert Shane, 201/389-6451.

June 4-6
NATIONAL CONFERENCE ON SYNCHROTRON RADIATION INSTRUMENTATION, NBS, Gaithersburg, MD; sponsored by NBS, Brookhaven National Laboratory, Stanford University, University of Wisconsin, and Cornell University; contact: David Ederer, A251 Physics Building, 301/921-2031.

June 11-15
SYMPOSIUM ON ACCURACY IN POWDER DIFFRACTION, NBS, Gaithersburg, MD; sponsored by NBS, National Research Council of Canada, and the International Union of Crystallography; contact: Stanley Block, A219 Materials Building, 301/921-2837.

June 18-20
FOURTH INTERNATIONAL SYMPOSIUM ON ULTRASONIC TISSUE CHARACTERIZATION, NBS, Gaithersburg, MD; sponsored by NBS and NIH, contact: Melvin Linzer, A329 Materials Building, 301/921-2858.

June 21
18TH ANNUAL ACM TECHNICAL SYMPOSIUM, NBS, Gaithersburg, MD; sponsored by NBS and ACM; contact: Seymour Jeffery, A247 Technology Building, 301/921-3531.

June 25
MINORITY BUSINESS MEETING, NBS Gaithersburg, MD; sponsored by NBS and NOAA; contact: Keith Chandler, Supply Building, 301/921-2696.

July 22-27
NATIONAL CONFERENCE ON WEIGHTS AND MEASURES, Red Lion Motor Inn, Portland, Oregon; sponsored by NBS and NCWM; contact: Harold Wollin, A211 Metrology Building, 301/921-3677.

August 13-15
SIMULATION, MANAGEMENT AND MODELING OF COMPUTER SYSTEMS, University of Colorado, Boulder, CO; sponsored by NBS; contact: Paul Roth, B250 Technology Building, 301/921-3545.

September 5-7
SYMPOSIUM ON EDDY CURRENT NONDESTRUCTIVE TESTING, NBS, Gaithersburg, MD; sponsored by NBS, ASTM and ASNT; contact: George Birnbaum, A363 Materials Building, 301/921-3331.

October 9-11
FOURTH ANNUAL CONFERENCE ON MATERIALS FOR COAL CONVERSION AND UTILIZATION, NBS Gaithersburg, MD; sponsored by NBS and DOE; contact: Samuel Schneider, B308 Materials Building, 301/921-2893.

***December 3-5**
1979 WINTER SIMULATION CONFERENCE, San Diego, California; sponsored by NBS, AIIE, ACM, IEEE, ORSA, TIMS, and SCS; contact: Paul Roth, B250 Technology Building, 301/921-3545.

* New Listings

PUBLICATIONS

TEACHER AIDS

by Stan Lichtenstein

The following materials produced by agencies of the Federal Government are recommended by DIMENSIONS/NBS for their potential value to educators as supplements to the classroom or school library.

16 Air and Water Pollution Issues Facing the Nation

This executive summary compresses into 44 pages a much larger General Accounting Office (GAO) study presented to Congress by the Comptroller General of the United States. Nine air pollution, four water pollution, and three "multimedia and general" issues are analyzed.

The discussion of Issue #14—"Pollution Created by Pollution Control"—exemplifies the executive summary's capsulization technique, with parallel columns headed "Background," "Issue," Our (GAO) View," and "Congressional and EPA Action (Recommended)." After raising the question of pollutants that have been removed and must then be disposed of "somewhere . . . (but) where?," the summary presents a GAO view in three succinct paragraphs emphasizing the need for a more integrated approach than that permitted by "single-purpose legislation and administration." The recommended Congressional and EPA action is outlined. Page number references to the Main Report are given for each issue.

Single copies free; additional, $1 per copy. Send single-copy requests to:
U.S. General Accounting Office
Distribution Section, Room 1518
441 G Street, N.W.
Washington, D.C. 20548

Lichtenstein is a writer and public information specialist in the Public Information Division.

Multiple-copy requests, accompanied by check or money order payable to GAO, should be sent to:
U.S. General Accounting Office
Distribution Section
P.O. Box 1020
Washington, D.C. 20013

EVALUATION OF METALLIC WINDOW FOIL FOR INTRUSION ALARM SYSTEMS

*Test Method for the Evaluation of Metallic Window Foil for Intrusion Alarm Systems, Stenbakken, G. N., Nat. Bur. Stand. (U.S.), Spec. Publ. 480-34, 5 pages (August 1978) Stock No. 003-003-01961-5, 90 cents.**

This publication describes a detailed test method for the evaluation of metallic foil used in intrusion alarm systems as a sensor to detect the breakage of glass.

Metallic foil is frequently used in intrusion alarm systems. The systems are designed so that breakage of the foil will cause the initiation of a local audible alarm or central alarm station. The foil is attached to the glass surface by means of an adhesive, sometimes precoated on one side of the foil, and is connected to the rest of the alarm circuit through terminal blocks. The alarm system control unit monitors the flow of electrical current through the foil and initiates an alarm signal if the current is interrupted.

The two performance attributes of metallic foil, totally under the control of the manufacturer, that determine whether it is suitable for use as an alarm sensor are: 1) its current carrying capacity, and 2) the manner in which the foil breaks when the glass to which it is attached is broken. The reliability of metallic foil as an alarm sensor is also influenced by the manner in which the installer attaches it to the glass and the quality of its electrical connection to the rest of the alarm circuit, factors not under the control of the manufacturer.

The procedure described in this publication has been used to determine whether metallic foil, adhesive bonded to glass in accordance with the manufacturer's instructions, would consistently generate an alarm signal when the glass was broken. A surprising number of metallic foil samples failed to break when the glass was broken, and would, therefore, not be suitable for use as an alarm sensor. The current carrying capacity of metallic foil was found, in all cases, to be consistent with normal alarm system requirements and was not addressed further.
Sponsored by: National Institute of Law Enforcement and Criminal Justice, Law Enforcement Assistance Administration, U.S. Department of Justice, Washington, D.C. 20531.

ASEISMIC DESIGN OF BUILDING SERVICE SYSTEMS

Aseismic Design of Building Service Systems: The State-of-the-Art, Yancey, C. W. C., and Camacho, A. A., Nat. Bur. Stand. (U.S.), Tech. Note 970, 83 pages (September 1978) Stock No. 003-003-01974-7, $2.50.

The current state-of-the-art of the design of earthquake-resistant building service systems is assessed in this study performed in the NBS Center for Building Technology. Until recently, most of the attention in the area of earthquake-resistant design has been concerned with mitigating damage to the structural systems rather than nonstructural systems involving electrical, plumbing, and mechanical components of the building, for instance.

This study, which focuses primarily on service systems essential to the continuous operation of hospital facilities in post-earthquake periods, provides a review of the literature pertaining to seismic performance of nonstructural systems. An evaluation of code and standards regulations applicable to the aseismic design of service system components is also presented, and information obtained from direct contact with several Federal agencies, the state of California, and practicing architects and engineers is summarized.

The report presents findings from a field visit to two hospitals currently under construction in earthquake-prone areas. It concludes by identifying deficiencies in current design/evaluation practices and providing a list of research needs in this area.

Acoustics and Sound

Pallett, D. S., Wehrli, R., Kilmer, R. D., and Quindry, T. L., Design Guide for Reducing Transportation Noise in and Around Buildings, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 84, 176 pages (Apr. 1978) Stock No. 003-003-01687-0, $3.50.

Atomic and Molecular Studies

Kurylo, M. J., and Braun, W., Eds., 12th Informal Conference on Photochemistry, held at the National Bureau of Standards, Gaithersburg, MD, June 28-July 1, 1976, Nat. Bur. Stand. (U.S.), Spec. Publ. 526, 411 pages (Oct. 1978) Stock No. 003-003-01984-4, $6.00.

Building Technology

Busching, H. W., Mathey, R. G., Rossiter, J., Jr., and Cullen, W. C., Effects of Moisture in Built-up Roofing—A State-of-the-Art Literature Survey, Nat. Bur. Stand. (U.S.), Tech. Note 965, 78 pages (July 1978) Stock No. 003-003-01944-5, $2.40.

Chapman, R. E., and Kowalski, J. G., Lead Paint Abatement Costs: Some Technical and Theoretical Considerations, Nat. Bur. Stand. (U.S.), Tech. Note 979, 153 pages (Feb. 1979) Stock No. 003-003-02022-2, $3.25.

Mahaffey, C. T., International Trends and Developments of Importance to the Metrication Plans of the U.S. Construction Community, Nat. Bur. Stand. (U.S.), Tech. Note 976, 72 pages (June 1978) Stock No. 003-003-01937-2, $2.40.

Orloski, M. J., and Wyly, R. S., Performance Criteria and Plumbing System Design, Nat. Bur. Stand. (U.S.), Tech. Note 966, 61 pages (Aug. 1978) Stock No. 003-003-01963-1, $2.40.

Rossiter, W. J., Jr., and Mathey, R. G., Elastomeric Roofing: A Survey, Nat. Bur. Stand. (U.S.), Tech. Note 972, 54 pages (July 1978) Stock No. 003-003-01954-2, $2.30.

Conti, D. M., Computer Science and Technology of the Standard Benchmark Library—Study Group, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-38, 57 pages (Jan. 1979) Stock No. 003-003-02009-5, $2.40.

Gass, S. I., Computer Science and Technology: Computer Model Documentation: A Review and An Approach, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-39, 89 pages (Feb. 1979) Stock No. 003-003 02020-6, $2.75.

Greenberg, H. J., and Kalan, J. E., Enhancing Fortran to Aid Manipulation of Large Structured Matrices, J. Res. Nat. Bur. Stand. (U.S.), *84*, No. 1, 21-47 (Jan.-Feb. 1979).

Kelly, J. C., and Route, G. P., Computer Science and Technology: UNIVAC 1108 EXEC Level 32R2, Performance Handbook, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-34, 144 pages (June 1978) Stock No. 003-003-01948-8, $3.25.

Mamrak, S. A., Amer, P. D., Computer Science and Technology: A Methodology for the Selection of Interactive Computer Services, Nat. Bur. Stand. (U.S.), Spec. Publ. 500-44, 82 pages (Jan. 1979) Stock No. 003-003 02018, $2.50.

Consumer Information and Protection:

Wollin, H. F., Ed., Report of the 62nd National Conference on Weights and Measures 1977. Proceedings of the 62nd National Conference on Weights and Measures, sponsored by the National Bureau of Standards, held in Dallas, TX, July 17-22, 1977, Nat. Bur. Stand. (U.S.), Spec. Publ. 517, 303 pages (Aug. 1978) Stock No. 003-003-01966-1, $4.25.

Electromagnetic Metrology

Hoer, C. A., Calibrating Two 6-Port Reflectometers with only one Impedance Standard, Nat. Bur. Stand. (U.S.), Tech. Note 1004 46 pages (June 1978) Stock No. 003-003-01956-9, $1.60.

Lawton, R. A., and Ondrejka, A. R., Antennas and the Associated Time Domain Range for the Measurement of Impulsive Fields, Nat. Bur. Stand. (U.S.), Tech. Note 1008, 68 pages (Nov. 1978) Stock No. 003-003 01998-4, $2.40.

Electronic Technology

Bullis, W. M., and Mayo-Wells, J. F., Jr., Semiconductor Measurement Technology: Progress Report, July 1 to September 30, 1976, Nat. Bur. Stand. (U.S.), Spec. Publ. 400-36, 78 pages (July 1978) Stock No. 003-003-01955-1, $2.75.

Energy Conservation and Production

Nimmo, M. H., and Phillips, C. W., International Project Catalog of Modular Integrated Utility Systems, Nat. Bur. Stand. (U.S.), Spec. Publ. 515, 455 pges (July 1978) Stock No. 003-003-01953-4, $6.50.

Rubin, A. I., Collins, B. L., and Tibbott, R. L., Window Blinds as a Potential Energy Saver—A Case Study, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 112, 85 pages (May 1978) Stock No. 003-003-01936 4, $2.50.

Streed, E. R., Thomas, W. C., Dawson, A. G., III, Wood, B. D., and Hill, J. E., Results and Analysis of a Round-Robin Test Program for Liquid-Heating Flat-Plate Solar Collectors, Nat. Bur. Stand. (U.S.), Tech. Note 975, 119 pages (Aug. 1978) Stock No. 003-003-01959-3, $3.

Failure Analysis

Shives, T. R., and Willard, W. A., Eds., MFPG: Product Durability and Life. Proceedings of the 27th Meeting of the Mechanical Failures Prevention Group, held at the National Bureau of Standards, Gaithersburg, MD, Nov. 1-3, 1977, Nat. Bur. Stand. (U.S.), Spec. Publ. 514, 188 pages (May 1978) Stock No. 003-003-01935-6, $3.75.

General Theoretical Chemistry and Physics

DiMarzio, E. A., and Guttman, C. M., Behavior of an Isolated Polymer Chain Residing in a Density Gradient of Segments, J. Res. Nat. Bur. Stand. (U.S.), *83*, No. 2, 165-167 (Mar.-Apr. 1978).

Low Temperature Science and Engineering

Zimmerman, J. E., and Flynn, T. M., Eds., Applications of Closed Cycle Cryocoolers to Small Superconducting Devices. Proceedings of a Conference held at the National Bureau of Standards, Nat. Bur. Stand. (U.S.), Spec. Publ. 508, 238 pages (Apr. 1978) Stock No. 003-003-01910-1, $4.25.

** Publications cited here may be purchased at the listed price from the Superintendent of Documents, U.S. Printing Office, Washington, D.C. 20402 (foreign: add 25%). Microfiche copies are available from the National Technical Information Service, Springfield, VA 22161. For more complete periodic listings of all scientific papers and articles produced by NBS staff, write: Editor, Publications Newsletter, Administration Building, National Bureau of Standards, Washington, D.C. 20234.*

NEWS BRIEFS

AVOIDING LANDSLIDES. Landslides have always been a concern of transportation officials. They occur on older roads, but also have happened on sections of the Interstate System in difficult terrain. Highways are sometimes built in landslide-prone areas because of insufficient knowledge of subsurface abnormalities. Working for the Federal Highway Administration, NBS researchers have been using microwave techniques to probe rock formations for abnormalities several meters deep. Preliminary results of laboratory and field-site experiments have been highly encouraging.

NEW SRM CATALOG. Over 1000 different materials are described in the new 1979-80 NBS Standard Reference Materials catalog. SRM's are well characterized, homogeneous, stable materials or artifacts with specific properties or components measured and certified by NBS. In fiscal year 1978 alone, NBS distributed 37 000 SRM's to more than 10 000 users. The catalog (NBS Special Publication 260) can be ordered from U.S. GPO, Wash., D.C. 20402, SD Stock No. 003-003-02048-6, for $3. Paperback, 102 pages. To obtain a copy of the current price list, write to the Office of Standard Reference Materials, NBS, Wash., D.C. 20234.

VOLUNTARY LAB ACCREDITATION PROCEDURES. Optional procedures recently announced by the Department of Commerce shorten the time required to start up a laboratory accreditation program requested by voluntary standards organizations and other private sector groups. The simplified procedures are part of the Department's National Voluntary Laboratory Accreditation Program, which draws upon NBS for technical support. The time-saving procedures appear in the April 25, 1979, Federal Register, pages 24274-24283.

MILESTONE PASSED IN ENERGY PROGRAM. A small U.S. business has developed an innovative solar collector, making it the 100th invention recommended for Government support in a unique program aimed at encouraging energy savings in the United States. Under this program, the NBS Office of Energy-Related Inventions (OERI) evaluates inventions and recommends those with promise to the Department of Energy for support in development and/or marketing. Since the program began in mid-1975, NBS has received more than 10 000 invention evaluation requests.

NEW EQUIPMENT STANDARD FOR LAW ENFORCEMENT AGENCIES. A performance standard for body-worn FM transmitters used by law enforcement personnel in undercover operations has been developed by NBS. Equipment which meets requirements in the standard is of superior quality and suited to the needs of law enforcement agencies. The National Institute of Law Enforcement and Criminal Justice sponsored this work.

NEXT MONTH IN

DIMENSIONS NBS

Rising costs and increased demand in the housing market are making the renovation of older homes an attractive alternative. Read about the problems and prospects of building rehabilitation in the next issue of DIMENSIONS/NBS.

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